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Patentanmeldung Nr. **Patent application No.** **Demande de brevet n°**

03300279.1

PRIORITY DOCUMENT

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Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

System for guiding a medical instrument in a patient body

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SYSTEM FOR GUIDING A MEDICAL INSTRUMENT IN A PATIENT BODY

FIELD OF THE INVENTION

The present invention relates to a system for guiding a medical instrument in a patient body. The invention also relates to a method to be used in said system. The invention finds for example its application for guiding a catheter inside the heart of a patient during an electrophysiology interventional procedure.

BACKGROUND OF THE INVENTION

Clinical applications in which a medical instrument has to be guided into the body of a patient are becoming widespread. Notably the growing interest in minimal-invasive methods for the treatment of cardiac diseases necessitates the development of methods and devices allowing the physician to guide a medical instrument to predetermined positions inside or outside the heart. In electrophysiology for example, it is necessary to guide a catheter to a plurality of predetermined positions on the ventrical or atrium wall in order to measure an electrical pulse or to burn wall tissues.

Systems currently available use X-ray fluoroscopy for visualizing the catheter. For its localization, said catheter comprises on its head an electromagnetic transmission device which transmits a signal to a plurality of electromagnetic receiving devices arranged outside the body. The problem is that, at the except of bones structures, X-ray fluoroscopy does not show the surrounding anatomy like for instance vascularities and soft tissues. To this end, a contrast agent is injected from times to times but not continuously. Consequently, the physician has to guide the medical instrument quasi blindly.

US patent 6,587,709 discloses a system for guiding a medical instrument into the body of a patient, which acquires a live 3D ultrasound image data set using an ultrasound probe. An advantage of acquiring a 3D image data set is to get depth information. An advantage of using a live 3D ultrasound image modality is that the surrounding anatomy becomes visible, which facilitates the guidance of the medical instrument by the physician. The system further comprises localization means for localizing the medical instrument within the 3D ultrasound data set, which locates three ultrasound receivers mounted on the medical instrument relatively to said ultrasound probe.

A first drawback of such a 3D ultrasound data set is to have a narrow image field, which does not cover the whole part of the patient body concerned by a catheter introduction and placement. Therefore, for guiding the catheter during the whole procedure, the

ultrasound probe has to be moved several times. At each displacement, a pre-operative step of locating the ultrasound probe in a referential of the interventional room is needed, because the location of the catheter is measured relatively to the ultrasound probe location. Such a pre-operative step may delay and complicate the interventional procedure.

A second drawback of the ultrasound imaging modality is to have a lower resolution than the X-ray imaging system. Therefore, the acquired 3D ultrasound data set does not give an improved image of the catheter.

A third drawback of the ultrasound imaging modality is that there are some zones of the patient body where the thoracic cage blocks the ultrasound scan and no exploitable image can be output.

SUMMARY OF THE INVENTION

The object of the invention is therefore to provide a solution for guiding a medical instrument in a patient body, which gives an improved visibility of the medical instrument and its surrounding anatomy during the whole procedure.

This is achieved by a system for guiding a medical instrument in a patient body comprising:

- X-Ray acquisition means for acquiring a two-dimensional X-ray image of said medical instrument,
- Ultrasound acquisition means for acquiring a three-dimensional ultrasound data set of said medical instrument using an ultrasound probe,
- means for localizing said ultrasound probe within a referential of said X-ray acquisition means,
- means for selecting a region of interest around said medical instrument within the 3D ultrasound data set,
- means for generating and displaying a bi-modal representation of said medical instrument in which said two-dimensional X-ray image and the three-dimensional ultrasound data included in said region of interest are combined.

With the invention, a bimodal representation is provided, in which two-dimensional (2D) X-ray data and three-dimensional (3D) ultrasound data are combined. Such a bimodal representation gives both the information about the bones structures and the medical instrument provided by the X-ray acquisition means and the information about the tissues and vascularities in a neighbourhood of the medical instrument provided by the ultrasound

acquisition means. Moreover, the three-dimensional ultrasound data set gives an indication of depth. Such a depth information is not available in the 2D X-ray image, which is a projection. The visibility of the medical instrument is therefore improved by the combination of the two modalities.

The system in accordance with the invention achieves a selection of a region of interest around the medical instrument within the 3D ultrasound data set. Such a selection, which is made either manually or automatically, aims at suppressing any ultrasound information which could occlude the medical instrument.

Advantageously a plane comprising comprising for instance the extremity of the medical instrument which is in contact with the wall tissue is selected within the region of interest.

In a first embodiment of the invention, the bimodal representation is generated on the basis of the 2D-X-ray image. In this 2D X-ray image all the X-ray intensity values of points having corresponding points in the selected plane of the 3D ultrasound data set are replaced by the ultrasound intensity values. An advantage of such a bimodal representation is to give an improved visibility of the wall tissues surrounding the medical instrument in terms of texture and depth.

Advantageously, the selection means comprises detection means for detecting the medical instrument within the region of interest. Such a detection is for instance achieved automatically by using image processing techniques, for instance a filter for enhancing elongated shapes. In the bimodal representation the X-ray intensity values of the points of the 2D X-ray image belonging to the detected medical instrument are not replaced. A first advantage is that the bimodal representation benefits from the high resolution of the medical instrument provided by the X-ray acquisition means.

A second advantage of this detection is that it requires no specific medical instrument. Considering that the medical instrument has to be changed for each new patient, another advantage of the system in accordance with the invention is to allow a non negligible cost savings.

A third advantage of this detection is that, combined with the bimodal representation, it helps generating of an electrical activation map of the heart cavity wall. As a matter of fact, in such a procedure, the medical instrument is a catheter equipped at its extremity with a sensor for measuring electrical pulses on a heart cavity wall. The user activates the sensor when the catheter is in contact-with-the-heart-cavity wall. A measurement of the electrical pulse at the current position of the catheter is made.The localization of the catheter provided

by the system in accordance with the invention allows building the point corresponding to said current position and said electrical measurement in the electrical activation map. The display of the bimodal representation offers to the user the possibility to evaluate a distance between the current measurement point and previous measurement points and therefore facilitates a quick, uniform and complete mapping of the cavity wall.

It should be noted that such a detection of the medical instrument within the 3D ultrasound data set is made possible by the fact that the ultrasound probe has firstly been localized within a referential of the X-ray imaging system, for instance a C-arm system as usually used in a cathlab room. Such a localization is for instance achieved by arranging three active localizers on the probe in order to get a 3D position of the probe in the referential of the X-ray imaging system. In an alternative, the probe is fixed on the patient body with a belt equipped with radio opaque markers, which can be detected in two distinct 2D X ray projection having a different and known orientation angle, either manually or automatically using image processing techniques. Consequently a 3D position of the probe in the referential of the X-ray imaging system can be deduced as well.

In a second embodiment of the invention, the system in accordance with the invention further comprises means for segmenting a wall tissue region in the 3D ultrasound data set. Therefore, in the 2D X-ray image, only the X-ray intensity values of the points belonging to said wall tissue region are replaced by the corresponding ultrasound intensity values. An advantage is that no perturbation is introduced by the ultrasound data in the closest vicinity of the medical instrument.

In a third embodiment of the invention, a volume rendering of the selected region of interest is provided. The bimodal representation is built up by replacing the intensity values of points of the 2D X-ray projection by the intensity values of the corresponding points in the volume rendered image. An advantage is to provide a perspective view of the surrounding tissues.

These and other aspects of the invention will be apparent from and will be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described in more detail, by way of example, with reference to the accompanying drawings, wherein:

Fig. 1 is a schematical drawing of a system in accordance with the invention,

- Fig. 2 is a schematical drawing of means for localizing the ultrasound probe within the X-ray referential, when the ultrasound probe is equipped with active localizers,
- Figs. 3, 4a and 4b are schematical drawings of means for localizing the ultrasound probe within the X-ray referential, when the probe is equipped with a belt comprising radio-opaque markers,
- Fig. 5 is a schematical drawing of means for localizing the medical instrument and determining a plane comprising said medical instrument within the 3D ultrasound data set in accordance with the invention,
- Fig. 6 is a schematical drawing of means for generating a bimodal representation in accordance with a first embodiment of the invention,
- Fig. 7 is a schematical drawing of means for generating a bimodal representation in accordance with a second embodiment of the invention,
- Fig. 8 is a schematical drawing of means for generating a bimodal representation in accordance with a third embodiment of the invention,
- Fig. 9 is a functional diagram of the method in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a system for guiding a medical instrument in a patient body. Such a system is particularly adapted for guiding a catheter within the heart cavities in order to diagnose and cure heart diseases, but it can more generally be used for guiding any other medical instrument in the patient body, like for instance a needle.

The schematical drawing of Fig. 1 shows a patient 1, who is arranged on a patient table 2 and whose symbolically indicated heart 3 is subjected to a treatment by means of a catheter 4 introduced into the body. The system comprises means 5 for acquiring a 2D X-ray image of the patient body. Said X-ray acquisition means comprise a focal X-ray source 6 and a detector 7. Advantageously, these X-ray acquisition means 5 are a C-arm system, as it is usually the case in a cathlab room. An advantage of such a C-arm system is to be able to have a rotational motion around the patient body in order to produce a plurality of 2D Xray images of the patient at known orientation angles.

The system in accordance with the invention further comprises means 8 for acquiring a three-dimensional (3D) ultrasound data set from an ultrasound probe 9, which has been placed on the patient body and fixed by fixation means, for instance a belt 10. It should be noted that both 2D X-ray image and 3D ultrasound data set are acquired in real-time, which

enables a live visualization of the medical instrument, when it is guided inside the patient body.

The X-ray acquisition means 5 comprise a referential of world coordinates (O, x, y, z), in which the geometry of the focal X-ray source 6 and the detector 7 is known.

The system in accordance with the invention further comprises means 11 for localizing the ultrasound probe 9 within the world referential (O, x, y) of the X-ray acquisition means 5, means 12 for detecting the catheter 4 within the 3D ultrasound data set and means 13 for generating a bimodal representation BI from the 2D Xray image, the 3D ultrasound data set, the localization of the 2D array probe 9 and the detection of the catheter 4. The bimodal image BI is displayed on a screen 14.

Referring to Fig. 2, the localization means 11 are, in a first approach, based on an active localizer 15, well-known to those skilled in the art, which is arranged on the ultrasound probe 9. Said active localizer 15, for instance an RF coil, is intended to transmit an RF signal to an RF receiving unit 16 placed under the patient body and for instance integrated into the table. The RF receiving unit transmits the received signal to measuring means 17 for measuring a position of the ultrasound probe 9 in a known referential, for instance the world referential (O, x, y, z) of the X-ray acquisition means 5. It should be noted that the active localizer 15 must be two-dimensional and placed on the ultrasound probe 9 in such a way that a precise measurement of the position and of the orientation of the ultrasound probe can be calculated. An advantage of this first approach is to provide a precise localization of the ultrasound probe.

In a second approach of the probe localization means 11 shown in Fig. 3, the ultrasound probe 9 is fixed around the body of the patient 1 with a belt 10 equipped with at least three non aligned interdependent radio-opaque markers M_1, M_2 and M_3. For instance, the belt 10 comprises a plexiglas plaque, in which the three non aligned interdependent radio-opaque markers are fixed.

The three markers M_1, M_2 and M_3 belong to a same plane, therefore at least two 2D different X-ray projections $2DXR_1$ and $2DXR_2$ acquired with different orientation angles θ_1 and θ_2 of the C-arm system 5 are needed in order to determine the position of the ultrasound probe in the world referential (O, x, y, z). However, since the three markers are interdependent, and non-aligned, which means that they form a rigid tetraedre, it is well-known to those skilled in the art that the position of the probe is completely specified by the two different X-ray projections $2DXR_1$ and $2DXR_2$.

Referring to Figs. 4a and 4b, we consider a detector referential (dO, dx, dy). It will appear to those skilled in the art that six parameters like for instance the coordinates (dx_1, dy_1), (dx_2, dy_2), (dx_3, dy_3) of the projections P_1, P_2, P_3 of the three markers M_1, M_2 and M_3 in the first 2D X-ray image $2DXR_1$ and the coordinates ($d'x_1$, $d'y_1$), ($d'x_2$, $d'y_2$), ($d'x_3$, $d'y_3$) of the projections P'_1, P'_2, P'_3 of the three markers M_1, M_2 and M_3 in the second 2D X-ray image $2DXR_2$ do completely specify the position of the ultrasound probe 9 in the world referential (O, x, y, z), provided that the difference of orientation angle between the two X-ray projections is known . Moreover, it should be noted that the localized points P_1, P_2, P_3 and P'_1, P'_2 and P'_3 follow epipolar constraints: this means for instance that a line L_1 linking the source focal point to the point P_1 appears as a projected line L'_1 in the second X-ray image $2DXR_2$, which comprises both P_1 and P'_1. A first advantage is that P'_1 has not to be searched within the whole image, but only on the projected line L'_1. A second advantage is that it gives a way of associating the points P_1, P_2, P_3 and P'_1, P'_2, P'_3 with the right markers M_1, M_2 and M_3.

An advantage of the radio-opaque markers M_1, M_2 and M_3 is to appear in a 2D X-projection with a very high contrast, which makes their localization easy and precise. Such a localiszation may be achieved manually or automatically. In the manual case, a user may click on at least two radio-opaque markers in each 2D X-ray projections. In the automatical case, image processing techniques well known to those skilled in the art, like for instance a morphological filter, may be used for detecting the radio-opaque markers, which appear as highly contrasted blobs in the 2D X-ray projections.

It should be noted that such a localization of the probe 9 is usually handled once in a preoperative step of a clinical procedure. As a matter of fact, with the invention, there is no need to move the ultrasound probe during the clinical procedure

Once the probe 9 has been located in the world referential (O, x, y, z), an orientation of the probe is known and therefore, the location of the 3D ultrasound data set 21 can be deduced. This is achieved by calculation means which calculate a position of a point of said 3D ultrasound data set in said referential from said ultrasound probe localization. A correspondance between points of the 3D ultrasound data set 21 and a 2D X-ray projection can immediately be deduced.

Referring to Fig. 5, the system in accordance with the invention comprises means 12 for selecting a region-of-interest 35 around the medical instrument 4 within the 3D ultrasound data set 21. In a first approach, the user interactively selects the region interest 35 in the 3D

ultrasound data set by defining a crop plane 30 such that everything which is placed in front of said crop plane 30 will not be displayed. In this way, structures which could occlude the medical instrument are removed. In an alternative a location of said crop plane is predefined, for instance at a predefined crop depth equal to a third of the depth of the 3D data set. This predefined crop plane may be further rotated for searching a viewing angle view within the 3D ultrasound data set from which the medical instrument is more visible. A rotated crop plane 33 is obtained. Advantageously said viewing angle is applied to the C-arm system in order to optimize the 2D X-ray image.

Advantageously the selection means 12 comprise means for detecting the medical instrument 4 within the 3D ultrasound data set 21. It should be noted that a medical instrument usually appears with a high contrast within the 3D ultrasound data set. It is for instance the case of an electrophysiology catheter, which comprises a metal tip at its extremity. Said tip is very echogen and leaves a specific signature in the 3D ultrasound data set. Therefore, said detection means involve image processing techniques, which are well known to those skilled in the art, for enhancing a highly contrasted elongated shape in a relatively uniform background.

It should be noted that such a detection of the medical instrument is performed in real-time and continuously during the clinical procedure. Therefore it can be assimilated to a tracking.

The detection means allow to automatically define the crop plane 30 by a point EP_1 and a normal orientation $\vec{N}$, where the point EP_1 for instance corresponds to the detected extremity of the medical instrument, for instance the extremity of the tip 31, and the normal orientation $\vec{N}$ to the known orientation 32 of the X-ray source 6.

In an alternative the crop plane 33 is defined by at least three non aligned points EP_1, EP_2 and EP_3 given by the detection of the medical instrument 4. A second normal $\vec{N}'$ is defined, which can advantageously serve for reorienting the X-ray source 6 in order to optimize the X-ray acquisition with respect to the detected position of the medical instrument 4.

The generation and display means 13 in accordance with the invention are intended to generate a bimodal representation of the medical instrument, in which information coming from both a 2D X-ray image and a 3D ultrasound data set are combined.

Preferably, such a combination is X-ray driven, which means that it is made on the basis of a 2D X-ray image 40, as shown in Fig. 5.

In a first embodiment of the invention, a 2D ultrasound view 41 corresponding to the ultrasound information contained in one of the previously defined planes 30, 33 including at least part of the medical instrument 4 is extracted from the 3D ultrasound data set 21 acquired at a time t.

A correspondance between points included into the 2D ultrasound view 41 and points included into the 2D X-ray image 40 can be calculated from the knowledge of the localization of the ultrasound probe 9 within the world referential (O, x, y, z) provided by the localization means 11.

The bimodal projection is formed such that the intensity values of all the points of the 2D X-ray projection 40 which have a corresponding point in the 2D ultrasound view 41 are replaced. An advantage is that the bimodal projection 45 obtained offers both an improved visibility of the surrounding tissues.

It is well known to those skilled in the art that the projection of the medical instrument given by the X-ray source 7 on the detector 7 is of good quality and benefits from high resolution and contrast. If a detection of the medical instrument within the region of interest of the 3D ultrasound data set has been made available by the detection means, then a position of the projection of the medical instrument 4 within the 2D X-ray projection 40, that is in the detector referential (dO, dx, dy), can be derived from the position of the medical instrument in the world referential (O, x, y, z). This position is for instance a set 43 of points of the X-ray projection corresponding to a set of points 42 within the 2D ultrasound view 41.

Advantageously, the intensity values of the points of the 2D X-ray projection 40 belonging to the detected medical instrument are not replaced by the corresponding ultrasound intensity values. An advantage is to keep the good visibility and resolution of the medical instrument provided by the X-ray acquisition means.

In a second embodiment of the invention shown in Fig. 6, the system in accordance with the invention further comprises means for segmenting a wall tissue region, for instance the endocardiac wall 44 in the neigbourhood of the medical instrument 4. This is achieved by image processing techniques such as intensity value thresholding, since wall tissues like myocardium appear brighter than blood in ultrasound images.

Another possibility is to use an active contour technique (also called "snake"). This technique, well known to those skilled-in-the-art,-firstly-consists in defining an initial contour and secondly in making said initial contour evolve under the influence of internal and

external forces. A final contour 46 is obtained. It is then possible to differentiate points located inside from points located outside the contour 46 and to replace only the outside points of the 2D X-ray projection 40 by the corresponding points of the 2D ultrasound view 41. An advantage of this second embodiment is to benefit from X-ray information in a larger neighbourhood of the medical instrument 4.

In a third embodiment of the invention schematically presented in Fig. 7, the system in accordance with the invention further comprises means for generating a volume rendered image 51 of the defined region of interest 35. Said volume rendered image 51 is used instead of the 2D ultrasound view 41 and combined with the 2D X-ray image 40 for generating a bimodal projection 52 in a similar way as previously described. An advantage of this third approach is to provide a perspective view of the neighbourhood of the medical instrument 4, for instance the heart cavities.

In a fourth embodiment of the invention, an alpha blending technique, well-known to those skilled in the art, is used for combining the X-ray intensity values of the points of the X-ray projection with the ultrasound intensity values of the corresponding points of the 3D ultrasound data set. An advantage of this fourth embodiment is to be very simple to implement.

It should be noted that the generation means 13 could inversely generate a bimodal representation on the basis of the 3D ultrasound data set and replace X-ray information by ultrasound information. However, it is of less interest, because in this case, the bimodal representation has an image field which is reduced to the one of the 3D ultrasound acquisition means.

It should be noted that the system in accordance with the invention has a particular interest for electrophysiology procedures, which consist either in generating an electrical activation map of a heart cavity wall for diagnosing heart diseases or in burning a zone of the wall tissue, which has been identified as abnormal. As a matter of fact, the system in accordance with the invention both provides a live visualisation of a large viewing field of the theater of operation, in which the medical instrument, the bone structures and the surrounding wall tissues are simultaneously visible and a live localization of the medical instrument, allowing a generation of the electrical activation map without further operation.

The invention also relates to a method of guiding a medical instrument in a patient body. Referring to Fig. 8, such a method comprises the steps of:

- localizing 60 an ultrasound probe 9 fixed on the patient body in a referential (O,x, y, z) of an X-ray imaging system 5,
- acquiring 61 at least an X-ray image 2DXR1 of said medical instrument 4 using said X-ray imaging system 5,
- acquiring 62 a 3D ultrasound data set 3DUS of said medical instrument 4 using said ultrasound probe 9,
- selecting 63 a region of interest 35 around the medical instrument 4 within the 3D ultrasound data set,
- generating and displaying 64 a bimodal image BI of said medical instrument 4 in which both 2D X-ray image 2DXR1 and 3D ultrasound data set 3DUS are combined.

The drawings and their description hereinbefore illustrate rather than limit the invention. It will be evident that there are numerous alternatives, which fall within the scope of the appended claims. In this respect the following closing remarks are made: there are numerous ways of implementing functions by means of items of hardware or software, or both. In this respect, the drawings are very diagrammatic, each representing only one possible embodiment of the invention. Thus, although a drawing shows different functions as different blocks, this by no means excludes that a single item of hardware or software carries out several functions, nor does it exclude that a single function is carried out by an assembly of items of hardware or software, or both.

Any reference sign in a claim should not be construed as limiting the claim. Use of the verb "to comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. Use of the article "a" or "an" preceding an element or step does not exclude the presence of a plurality of such elements or steps.

CLAIMS

1. A system for guiding a medical instrument in a patient body comprising:

- X-Ray acquisition means for acquiring a two-dimensional X-ray image of said medical instrument,
- Ultrasound acquisition means for acquiring a three-dimensional ultrasound data set of said medical instrument using an ultrasound probe,
- means for localizing said ultrasound probe within a referential of said X-ray acquisition means,
- means for selecting a region of interest around said medical instrument within the 3D ultrasound data set,
- means for generating and displaying a bi-modal representation of said medical instrument in which said two-dimensional X-ray image and the three-dimensional ultrasound data included in said region of interest are combined.

2. A system as claimed in claim 1, wherein said localization means are intended to localize an active localizer, which has been arranged on said ultrasound probe.

3. A system as claimed in claim 1, wherein said ultrasound probe is equipped with at least three non aligned and interdependent radio-opaque markers and said localization means are intended to localize said markers in a first 2D X-ray image having a first orientation angle and in a second 2D X-ray image having a second orientation angle in said referential.

4. A system as claimed in claim 1, comprising calculation means for calculating a position of a point of said 3D ultrasound data set in said referential from said ultrasound probe localization.

5. A system as claimed in claim 1, wherein said localization means are intended to select a plane comprising said medical instrument within said region of interest.

6. A system as claimed in claim 1, wherein said generating means are intended to generate said bimodal-representation on the basis of said 2D X-ray image by

replacing X-ray intensity values of points of the 2D X-ray image by ultrasound intensity values of the corresponding points of said region of interest.

7. A system as claimed in claims 5 and 6, wherein the corresponding points of said region of interest belong to said plane.

8. A system as claimed in claim 6, wherein said generating means are intended to generate a volume rendered view of said region of interest within said 3D ultrasound data set and said corresponding points belong to said volume rendered view.

9. A system as claimed in claim 1, wherein said selection means comprise means for detecting said medical instrument within said region of interest.

10. A system as claimed in claims 6 and 9, wherein the X-ray intensity values of points of the detected medical instrument are not replaced by the ultrasound intensity values of the corresponding points of said region of interest.

11. A system as claimed in claim 6, comprising means for segmenting a wall tissue region in the 3D ultrasound data set and said generating means are intended to replace the X-ray intensity values of the points belonging to said wall tissue region by the ultrasound intensity values of the corresponding points of said region of interest.

12. A method of guiding a medical instrument in a patient body, comprising the steps of:

- localizing an ultrasound probe fixed on the patient body in a referential of an X-ray imaging system,
- acquiring at least an X-ray image of said medical instrument using said X-ray acquisition system,
- acquiring a 3D ultrasound data set of said medical instrument using said ultrasound probe,
- localizing said ultrasound probe in a referential of said X-ray acquisition system,
- selecting a region of interest of said medical instrument within said 3D ultrasound data set,

- generating and displaying a bimodal representation of said medical instrument in which both 2D X-ray image and the 3D ultrasound data included in said region of interest are combined.

SYSTEM FOR GUIDING A MEDICAL INSTRUMENT IN A PATIENT BODY

ABSTRACT

The present invention relates to a system for guiding a medical instrument in a patient body. Such a system comprises means for acquiring a 2D X-ray image of said medical instrument, means for acquiring a 3D ultrasound data set of said medical instrument using an ultrasound probe, means for localizing said ultrasound probe in a referential of said X-ray acquisition means, means for selecting a region of interest around said medical instrument within the 3D ultrasound data set and means for generating a bimodal representation of said medical instrument detection by combining said 2D X-ray image and said 3D ultrasound data set. A bimodal representation is generated on the basis of the 2D X-ray image by replacing the X-ray intensity value of points belonging to said region of interest by the ultrasound intensity value of the corresponding point in the 3D ultrasound data set.

Reference: Fig. 1

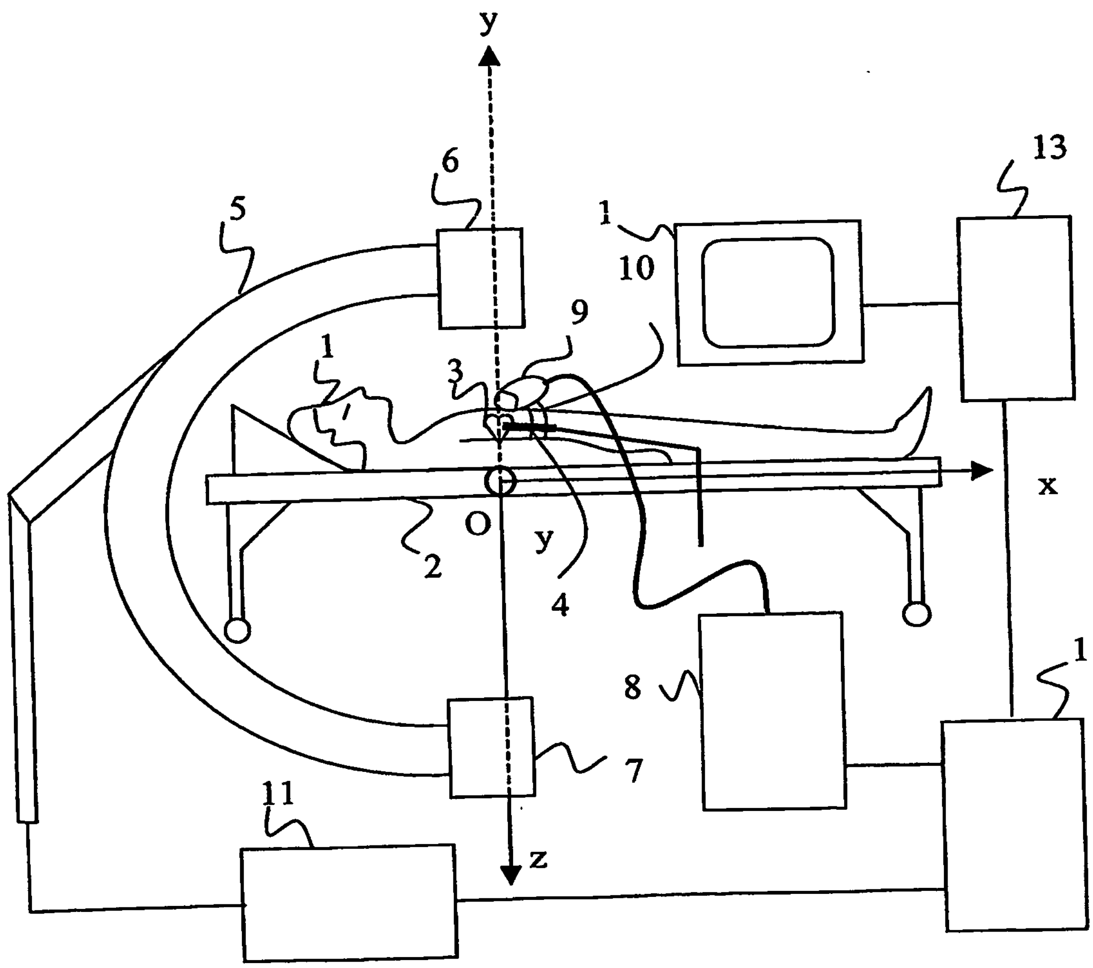

FIG. 1

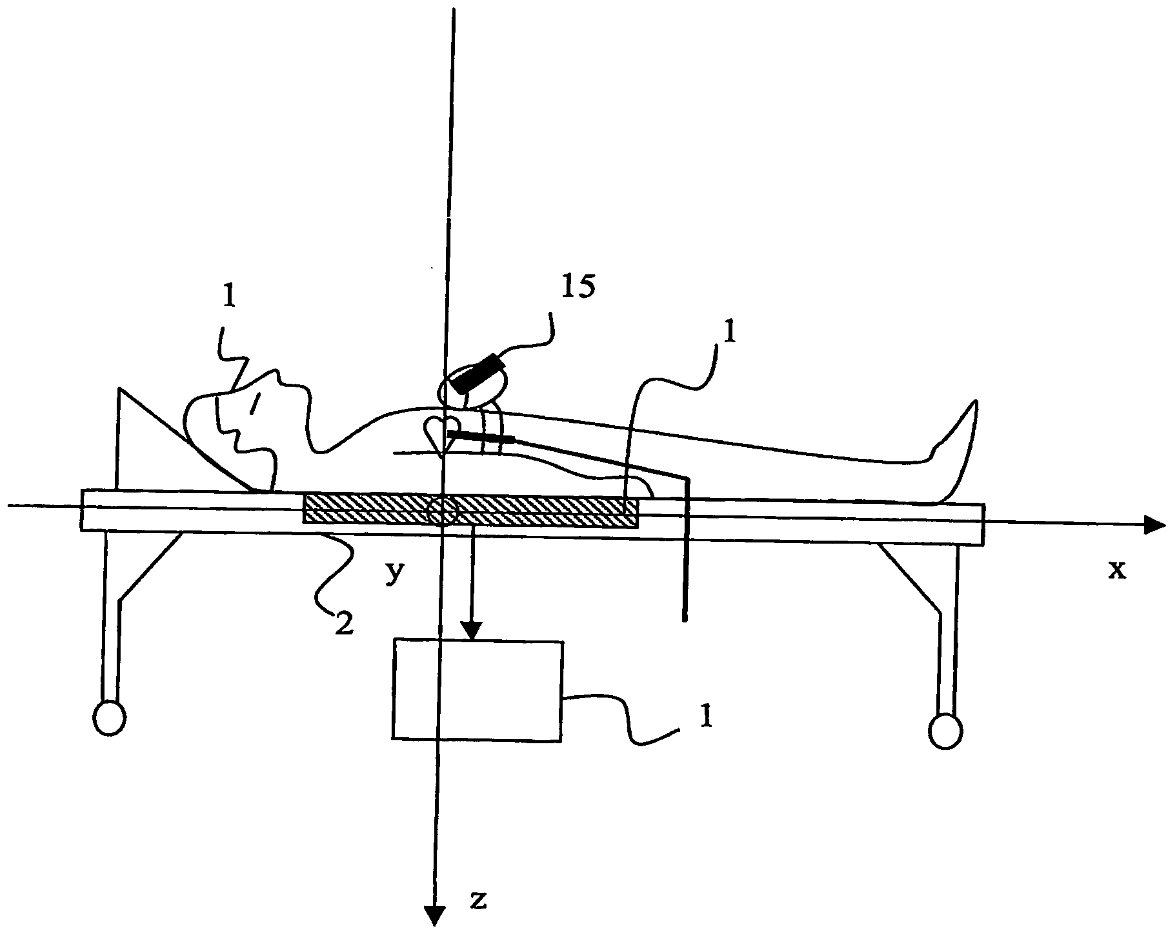

FIG. 2

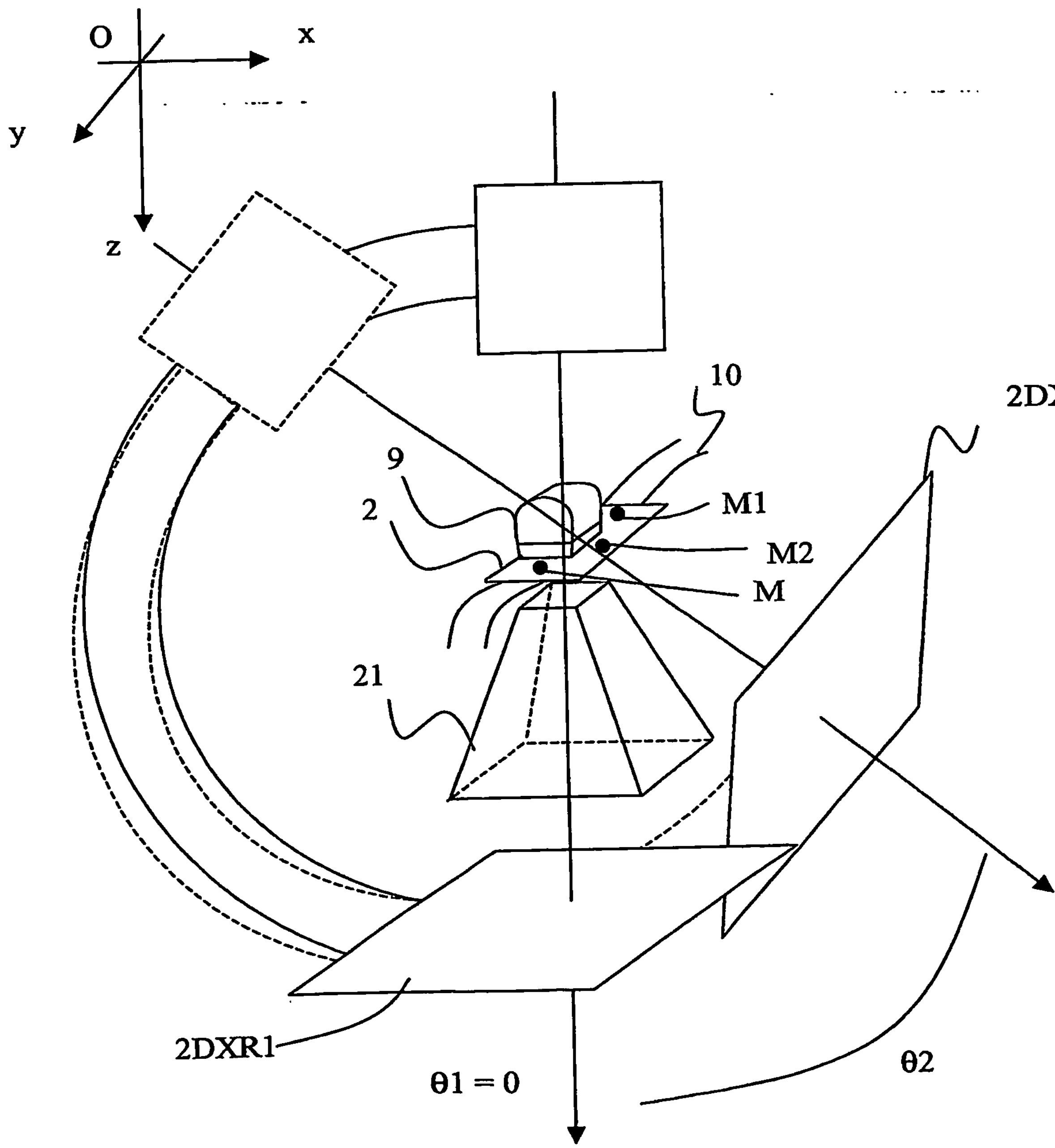

FIG. 3

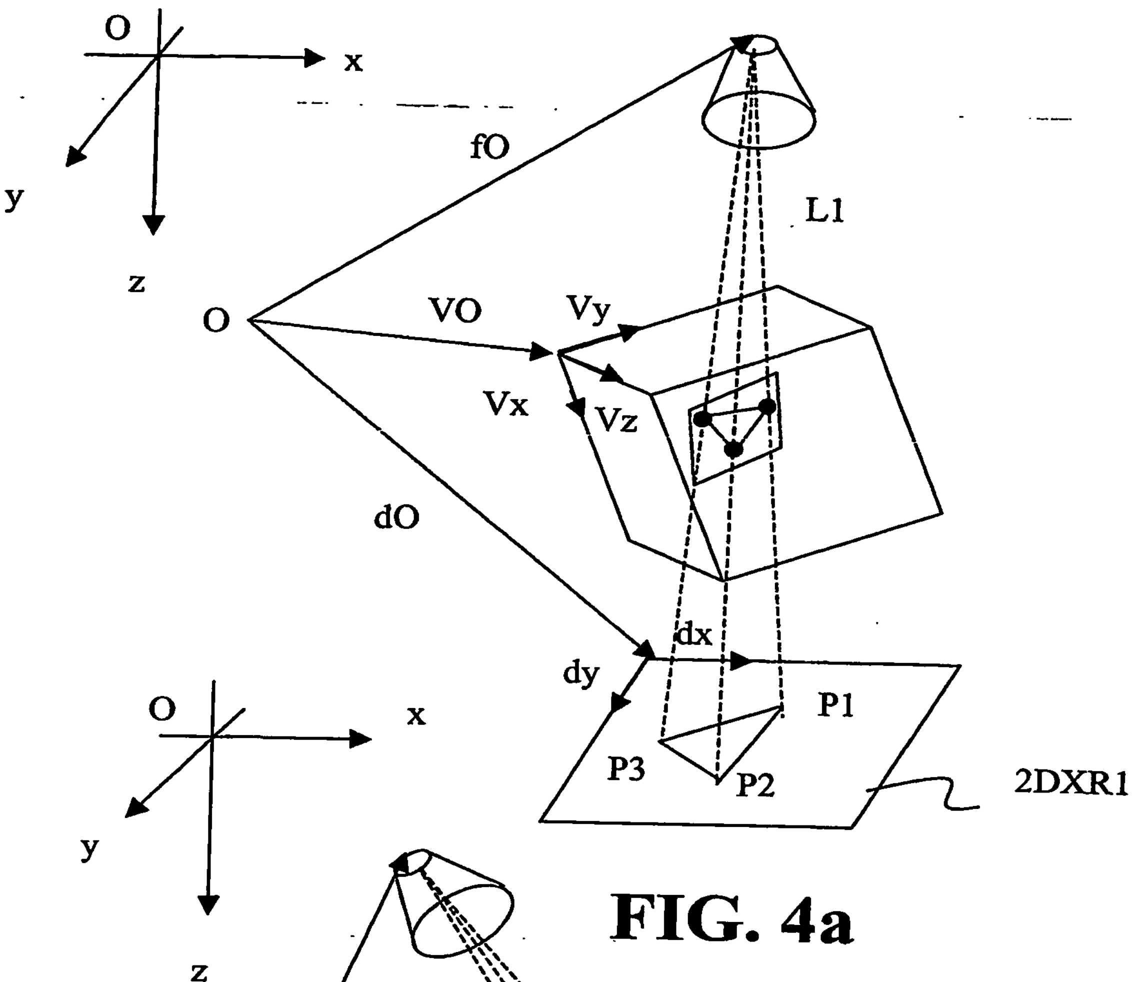
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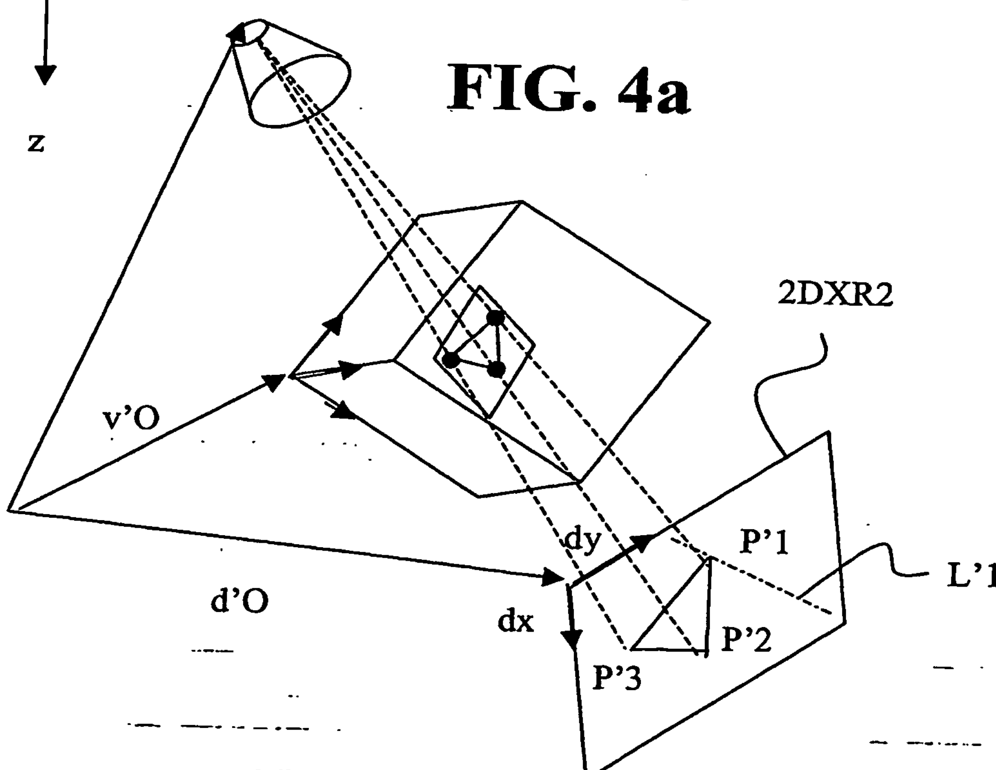
FIG. 4a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v'O
dy
P'1
L'1
d'O
dx
P'2
P'3

FIG. 4b

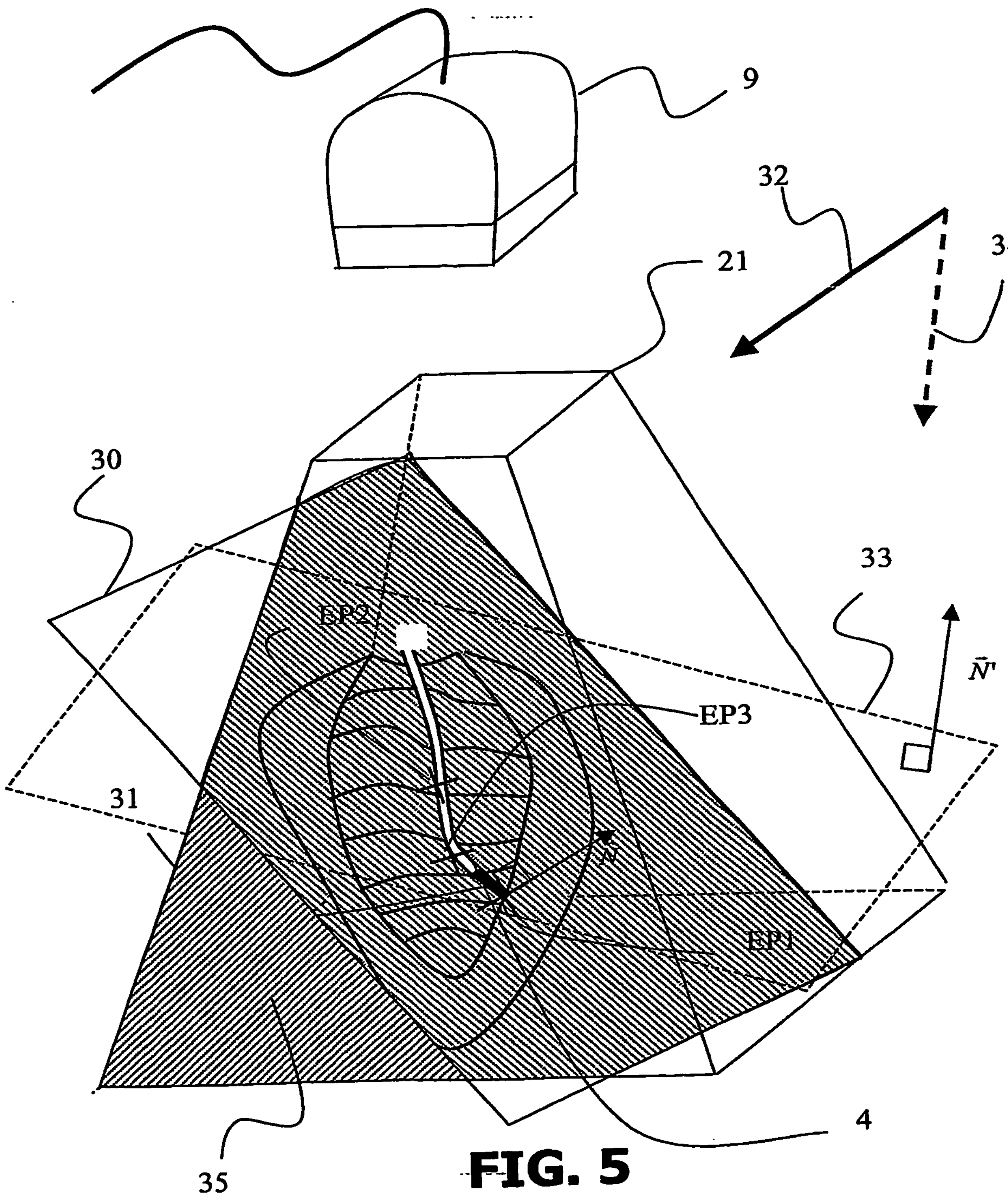

FIG. 5

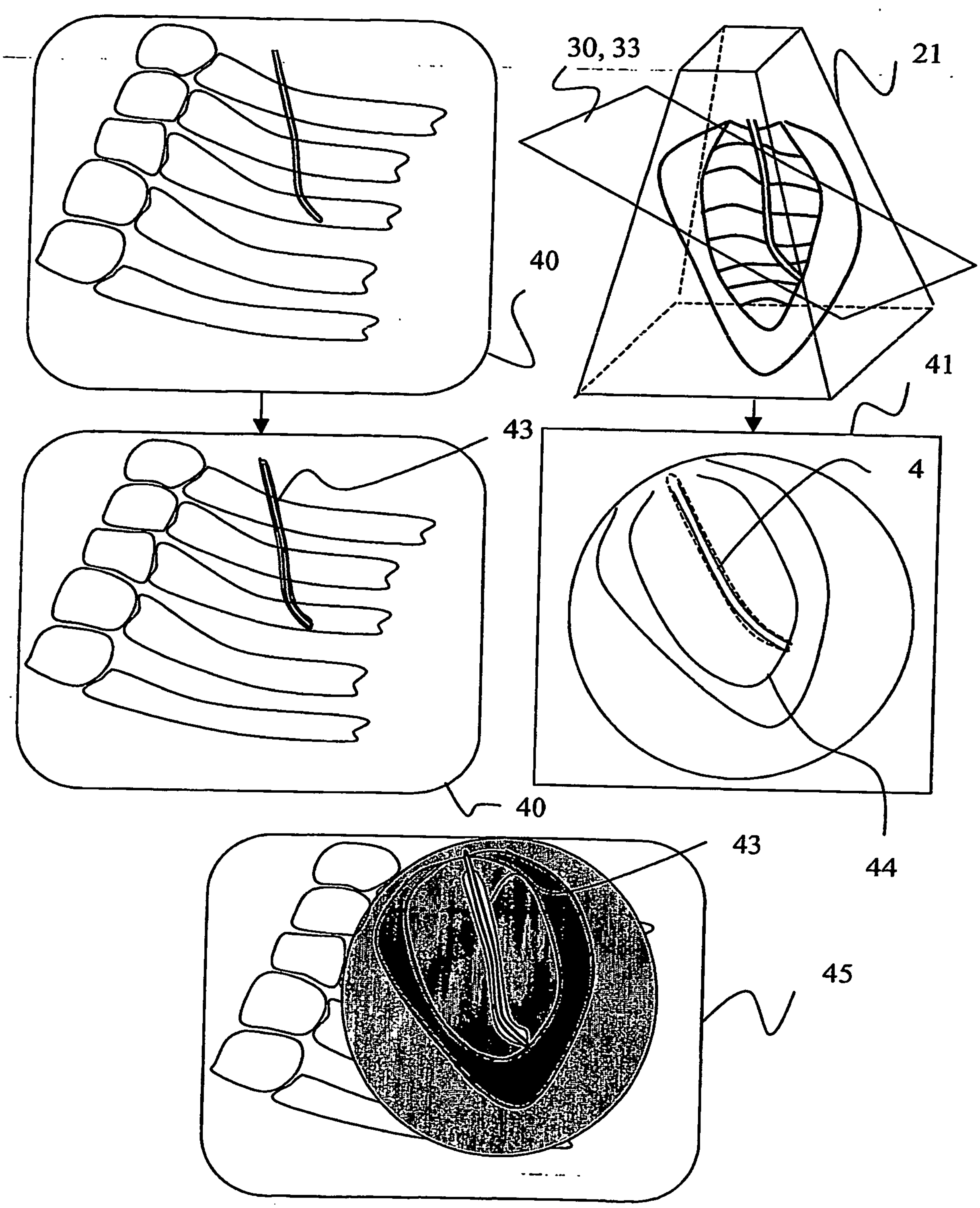

FIG. 6

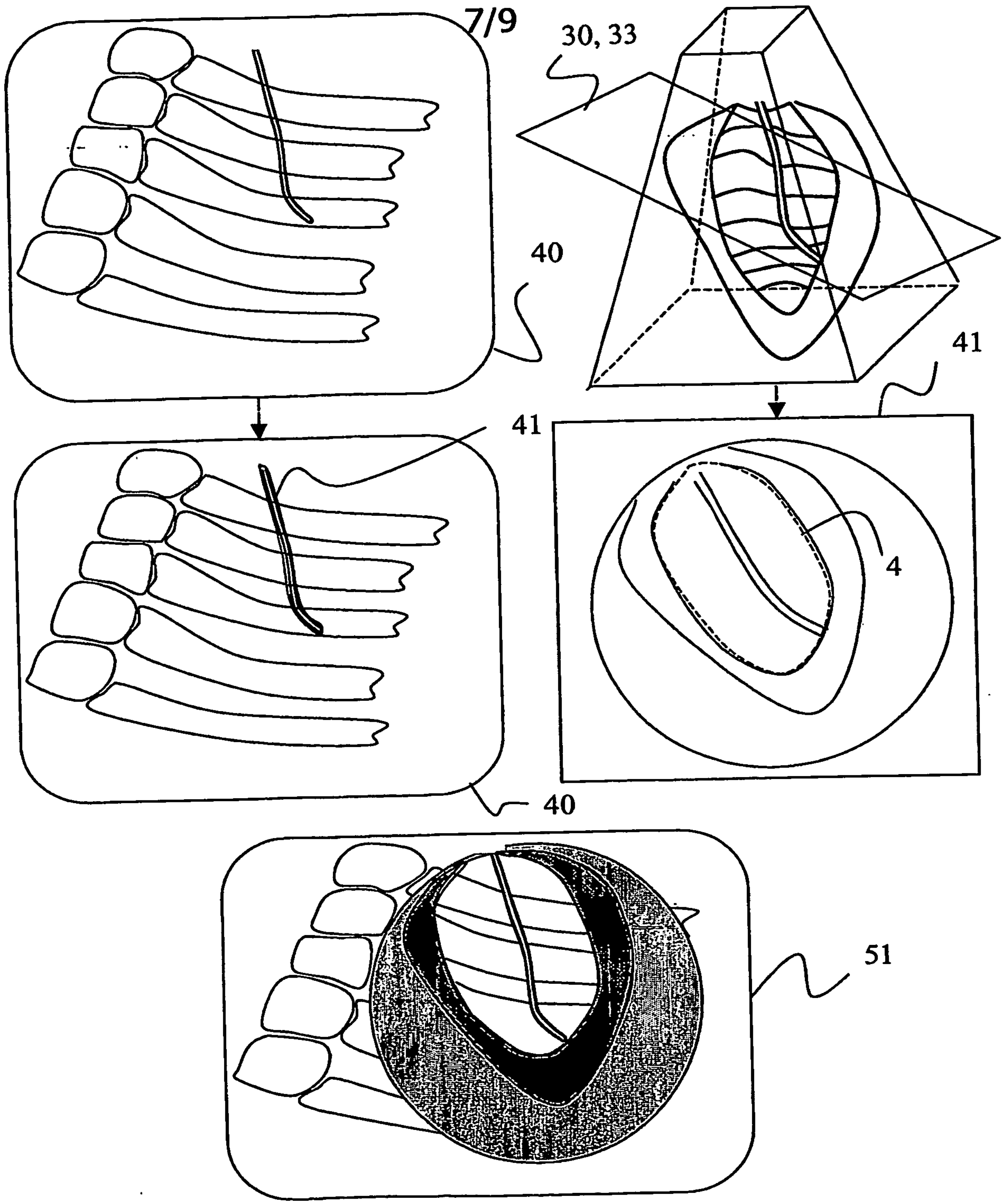

FIG. 7

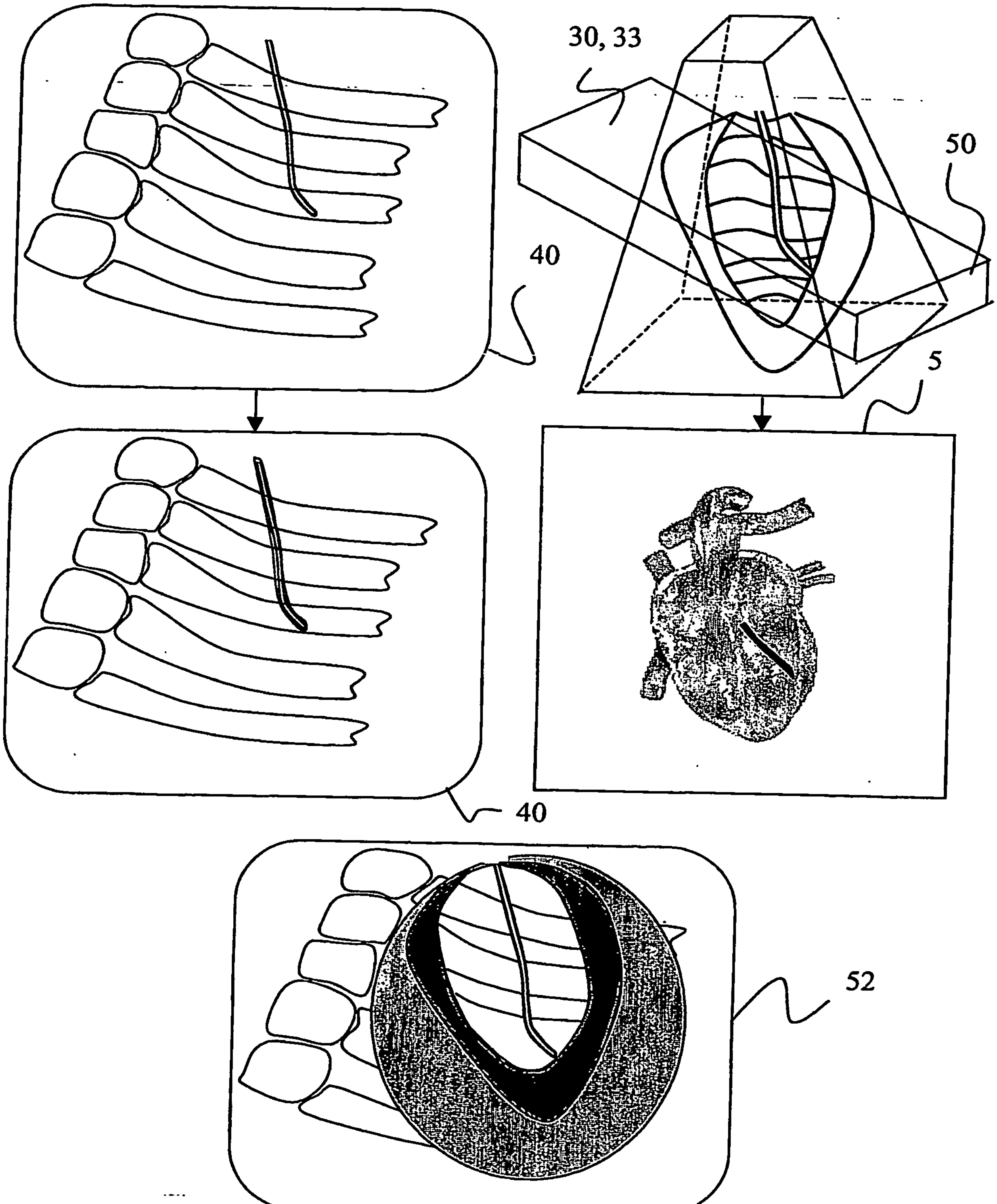

FIG. 8

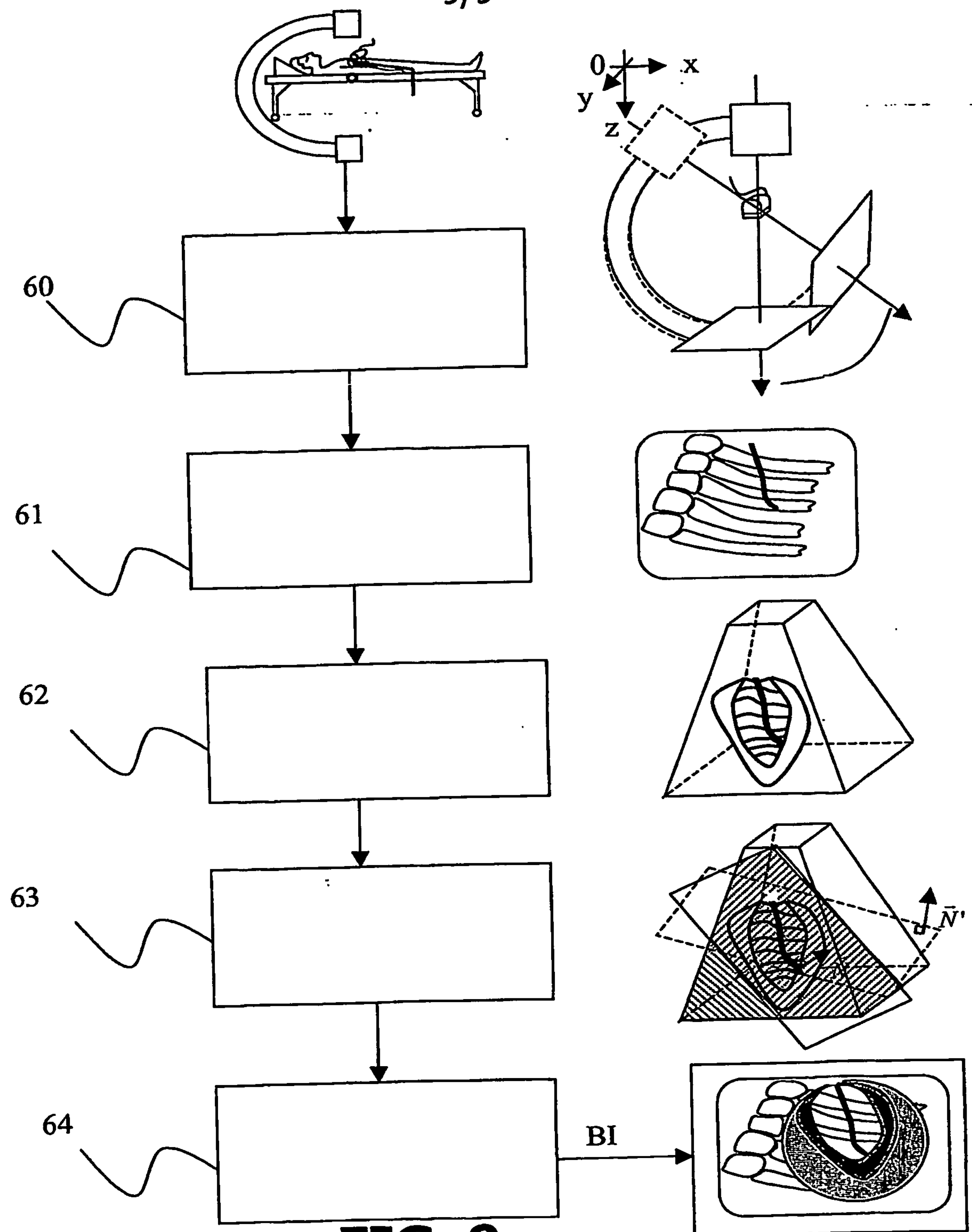

FIG. 9

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